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Yields and Trends of Nutrients and Total Suspended Solids in Nontidal Areas of the Chesapeake Bay Basin, 1985-96

INTRODUCTION

Excessive concentrations of nutrients and suspended solids in water adversely affect water quality in the Chesapeake Bay. High levels of nutrients in the Bay result in algal blooms and suspended solids reduce water clarity, both of which decrease the amount of light reaching submerged aquatic vegetation (SAV). The die off and decomposition of algae and SAV deplete oxygen supplies in the water. Low dissolved oxygen (DO) levels (less than 5.0 milligrams per liter for aquatic life, U.S. Environmental Protection Agency, 1986) can lead to fish kills and stress other living resources in the Bay. In 1987, the Chesapeake Bay Agreement called for a 40-percent reduction in the amount of controllable nutrients reaching the Chesapeake Bay by the year 2000. This goal was based on results of computer simulations that predicted that periods of low DO would be reduced or eliminated if nutrient inputs to the Bay were reduced by that amount. In an effort to achieve that goal, nutrient-reduction strategies, including banning phosphate detergents, upgrading sewage-treatment plants, controlling runoff from agricultural and urban areas, and preserving forest and wetland areas (Zynjuk, 1995), were implemented in many areas of the basin to help reduce nutrient inputs to the Bay.

In 1997, a basinwide reevaluation of the 40-percent reduction goal was initiated to determine if that goal is achievable and to identify and document any changes in water quality and living resources in response to nutrient-reduction strategies. In support of this reevaluation, the U.S. Geological Survey (USGS) designed a database and retrieved water-quality data from approximately 1,300 nontidal stream sites in the Chesapeake Bay Basin (Langland and others, 1995). At 84 of the 1,300 sites, where sufficient data were available, trends, yields, and annual loads of nutrients and suspended solids were estimated for 1985 through 1996. This report presents: (1) spatial distribution of available nutrient and suspended-solids data for the 84 sites, (2) yields of nutrients and total suspended solids, and (3) trends in concentrations of nutrients and total suspended solids. Results presented here are limited to analyses for total nitrogen (TN), nitrate nitrogen (NO_3), total phosphorus (TP), and total suspended solids (TSS).

SPATIAL DISTRIBUTION

The 84 sites selected for analysis, which drain areas ranging from 3.3 to 27,100 square miles, are distributed throughout 10 major river basins in the 64,000-square-mile Chesapeake Bay Basin (fig. 1). Most of the 84 sites are in the basins of the three largest rivers draining into the Bay: the Susquehanna (36 sites), the Potomac (24 sites), and the James (9 sites). These three rivers drain slightly more than 80 percent of the Chesapeake Bay Basin and contribute about 85 percent of the Bay's mean annual inflow of 69,900 cubic feet per second.

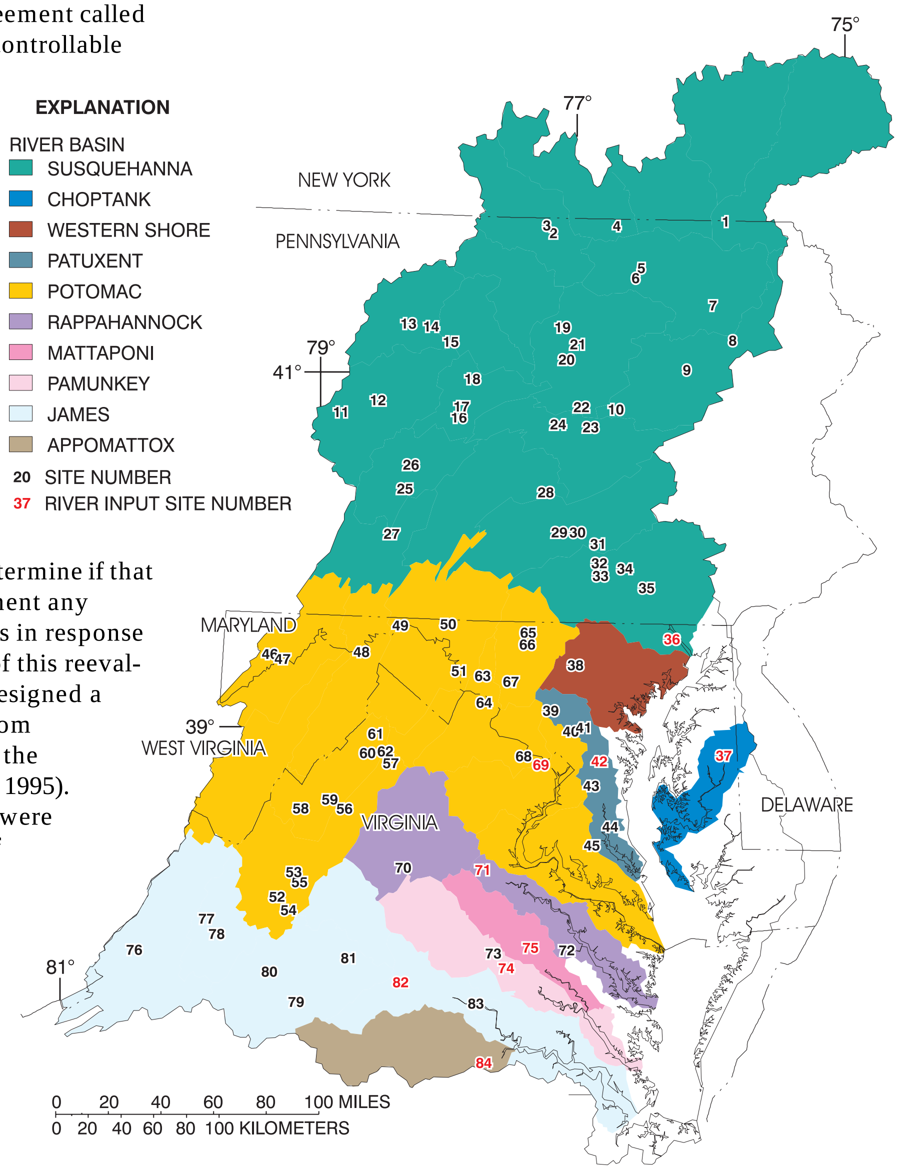

Figure 1. Locations of the 84 sites in the Chesapeake Bay Basin used for analysis in this study.

Data from some areas in the Chesapeake Bay Basin are not discussed in this report because little or no long-term water-quality information is available. One example of this is the eastern shore of Maryland, an area previously identified as having elevated concentrations of nutrients (Zynjuk, L.D., and Feit, B.L., U.S. Geological Survey, written commun., 1996).

YIELDS

In order to calculate an annual yield of a constituent from a stream basin, an annual load (concentration multiplied by streamflow) must first be estimated. Annual loads of TN, NO_3, TP, and TSS at the 84 sites were estimated by use of the USGS seven-parameter log-linear-regression model (ESTIMATOR) developed and validated by Cohn and others (1992). This model incorporates the minimum variance unbiased estimator (MVUE) model developed by Bradu and Mundlak (1970). The USGS model uses multiple regression to estimate a daily load by multiplying a predicted daily concentration by the daily mean streamflow. The estimated daily loads are summed to estimate the annual load. Annual yields are then calculated as the annual load divided by the drainage basin area. To be consistent with reporting of data in the 1997 reevaluation of the Chesapeake Bay Program (Langland and others, 1998), a mean yield based on annual yields for calendar years 1994-96 is reported here. If 1994-96 annual yields are not available, then the mean annual yield from 1993 to 1995 is reported. The mean annual yields discussed in this report will hereafter be referred to as status yields.

Sampling several high-flow events at different times of the year is extremely important in making accurate estimates of loads and yields. If a concentration-streamflow relation is not accurately defined, annual loads (and therefore annual yields) potentially can be over- or underestimated. Previous studies (Langland and others, 1995; Johnson and Belval, 1998) compared results of analysis of water-quality samples collected at the same site by different agencies over a 5-10 year period. Results indicated large differences in annual loads of TN, TP, and TSS at many of these co-located sampling sites, especially in basins where concentrations vary considerably between stormflow and non-stormflow conditions. These differences are directly related to the presence or absence of samples that represented the entire range of streamflow, especially the high-flow events. Therefore, sampling schemes should be designed to include sampling of the entire range of streamflow conditions to ensure the best possible estimate of annual loads.

Status yields for TN were computed for 54 of the 84 sites (table 1). TN yields could be calculated for only 8 of the 36 sites in the Susquehanna River Basin because one or more nitrogen species needed to calculate TN (ammonia, organic nitrogen, nitrite, and nitrate) were not analyzed, or at least two of the species were reported at less than the analytical detection limit.

The three sites having the highest status yields for TN (site numbers 35, 51, and 50, fig. 1 and table 1) were located in highly intensive agricultural areas of the lower Susquehanna and the northcentral Potomac River Basins. More than 50 percent of the land that drains to the three sites is classified as agricultural. The Conestoga River (site 35) had a TN status yield of about 42 lb / acre (pounds per acre), more than five times the mean yield (8.4 lb / acre) of all the sites. Conversely, the lowest TN status yields (site numbers 62, 77, and 78, fig. 1 and table 1) were from basins that have a high (greater than 65) percentage of forest cover and a low (less than 20) percentage of agricultural land (Langland and others, 1995). Generally, these sites are in the central and western parts of the Chesapeake Bay Basin, where forests predominate and agricultural activity is less intense because of poor soil conditions and terrain unsuitable for farming.

Status yields of NO_3 (some sites have nitrite plus nitrate results, $NO_2 + NO_3$, and are noted in table 1) were calculated for 80 of the 84 sites (table 1). These 80 sites provide good areal coverage of the Chesapeake Bay Basin. Status yields represent both the total (56 sites) and dissolved (24 sites) forms of NO_3 (table 1). Because NO_3 is a major component of TN, generally the sites with the highest status yields of TN also have the highest yields of NO_3.

The highly intensive agricultural areas in the lower Susquehanna and central Potomac River Basins contain 9 of the 10 sites with the highest NO_3 yields. The highest yields for TN and NO_3 were reported at the same location—Conestoga River at Conestoga (site 35, fig. 1). Elevated yields of nutrients in agricultural areas are associated with nitrogen inputs, primarily from applications of manure and commercial fertilizers in excess of crop uptake. Lindsey and others (1997) estimated that on an annual basis, about 30 lb / acre of excess nitrogen were applied in the Conestoga River Basin in 1993-95. This excess nitrogen is potentially available to run off in surface water or to leach into the soil and enter the ground-water system. Conversely, status yields for NO_3 were lowest (averaging 1.21 lb / acre, sites 75-81, fig. 1 and table 1) in the highly forested upper James River Basin.

Status yields of TP were calculated at 75 of the 84 sites (table 1). Many of the sites that have high TP status yields are in the same highly intensive agricultural areas in the Chesapeake Bay Basin in which the highest status yields of TN and NO_3 were measured. Applications of manure and commercial fertilizer in excess of crop uptake requirements are the most likely cause of these high TP yields. Excess phosphorus adheres to soil particles and is readily transported in surface runoff when soils are disturbed by farming activities. The highest status yield of TP (3.53 lb / acre) was estimated at Conestoga River at Conestoga (site 35, fig. 1), an area of intensive agricultural activities. The lowest TP yield (0.11 lb / acre) was estimated for site 15, a small watershed within the Susquehanna River Basin where forest cover exceeds 90 percent of the drainage area. Additional factors contributing to elevated TP yields include the natural concentrations of phosphorus in the soils and the effects of urban growth in the basin.

Calculated TP yields decreased significantly between site 34 (0.61 lb / acre) and site 36 (0.30 lb / acre) in the Lower Susquehanna River Basin, even though the basin having the highest TP yield (site 35) discharged to the Susquehanna River between the two sites. The reason for this decrease is

Table 1. *Estimated and ranked yields for four constituents at 84 nontidal sites located within 10 river basins in the Chesapeake Bay Basin*

[N, nitrogen; P, phosphorus; yield, 1994-96 calendar year mean, in pounds per acre; rank (54), ranking of all yields from largest to smallest; number in parenthesis represents total number of sites with estimated yields; --, data not available; green, samples collected by the Susquehanna River Basin Commission; yellow, samples collected by the U.S. Geological Survey; purple, samples collected by the Metropolitan Washington D.C. Council of Governments; white, samples collected by State Regulatory Agencies, including the Maryland Department of Natural Resources, the Pennsylvania Department of Environmental Protection, and the Virginia Department of Environmental Quality]

U.S. Geological Survey streamflow site number	Water-quality site ID number	Map site number	Drainage area (square miles)	Total nitrogen as N		Nitrate nitrogen as N		Total phosphorus as P		Total suspended solids	
				Yield	Rank (54)	Yield	Rank (80)	Yield	Rank (75)	Yield	Rank (56)
SUSQUEHANNA RIVER BASIN											
01503000	WQN0306	1	2,232	--	--	3.26	55	0.35	[1]51	--	--
01518700	WQN0319	2	446	--	--	[2]2.54	62	[2].34	53	[2]120	36
01520000	WQN0320	3	298	--	--	3.12	57	.48	39	380	12
01531000	WQN0332	4	2,530	--	--	3.59	49	.36	[1]49	212	24
01531500	01531500	5	7,797	6.4 0	31	3.71	47	.58	28	461	8
01532000	WQN0318	6	215	--	--	--	--	.89	15	--	--
01534000	WQN0317	7	383	--	--	3.27	54	.28	[1]61	--	--
01536000	WQN0313	8	332	--	--	4.43	38	.91	14	110	39
01536500	WQN0302	9	9,960	--	--	3.19	56	.40	47	--	--
01540500	01540500	10	11,220	7.13	26	4.14	41	.62	[1]24	396	11
01541000	WQN0406	11	315	--	--	4.89	34	.49	[1]37	291	15
01541500	WQN0422	12	371	--	--	3.42	52	.24	66	180	27
01543000	WQN0420	13	272	--	--	3.45	51	.16	69	82.9	42
01544000	WQN0419	14	245	--	--	4.04	43	.13	[1]71	35.4	51
01545000	WQN0434	15	233	--	--	3.31	53	.11	75	13.8	56
01546500	WQN0415	16	87.2	--	--	14.9	10	.31	[1]57	71.7	43
01547200	WQN0413	17	265	--	--	11.0	13	.28	[1]60	--	--
01547950	WQN0423	18	152	--	--	2.29	63	--	--	33.8	53
01550000	WQN0409	19	173	--	--	6.69	26	.33	[1]54	35.3	52
01551500	WQN0402	20	5,682	--	--	3.63	48	.43	42	245	22
01552000	WQN0408	21	443	--	--	4.86	35	.13	[1]71	31.9	54
01553500	01553500	22	6,850	7.12	27	4.21	40	.42	[1]43	168	29
01554000	WQN0203	23	18,300	--	--	4.33	39	.46	[1]40	--	--
01555000	WQN0229	24	310	--	--	9.70	18	.28	[1]60	90.6	41
01556000	WQN0224	25	291	--	--	9.89	17	.78	21	--	--
01558000	WQN0217	26	220	--	--	6.31	28	.35	[1]51	--	--
01562000	WQN0223	27	756	--	--	9.92	15	.31	[1]57	--	--
01567000	01567000	28	3,354	9.51	17	7.00	23	.41	46	70.0	44
01570000	WQN0213	29	470	19.1	6	18.6	5	.50	[1]35	283	17
01570500	01570500	30	24,100	--	--	4.73	36	.46	[1]40	--	--
01573560	WQN0211	31	483	--	--	22.5	3	.62	[1]24	--	--
01574000	WQNO210	32	510	--	--	13.5	11	1.3	7	--	--
01575500	WQN0207	33	222	--	--	18.0	6	1.1	[1]8	--	--
01576000	0157600	34	25,990	9.60	16	6.54	27	.61	26	564	4
01576754	01576754	35	470	42.0	1	39.8	1	3.5	1	348	13
01578310	01578310	36	27,100	9.74	15	7.56	21	.33	59	193	26
CHOPTANK RIVER BASIN											
01491000	01491000	37	113	7.91	23	5.12	33	.42	[1]43	109	40
WESTERN SHORE RIVER BASIN											
01586000	NPA0165	38	56.6	19.7	5	16.3	8	--	--	--	--
PATUXENT RIVER BASIN											
01591000	01591000	39	34.8	13.7	9	10.2	14	.65	23	--	--
01592500	PXT0809	40	132	5.15	35	2.81	60	.12	74	29.0	55
01594000	01594000	41	98.4	10.0	14	5.48	30	--	--	--	--
01594440	01594440	42	348	7.93	22	5.15	32	.53	31	229	23
01594526	01594526	43	89.7	--	--	[1]1.64	65	--	--	--	--
01594670	01594670	44	9.4	1.95	50	.530	78	--	--	--	--
01594710	01594710	45	3.3	8.07	21	3.89	44	1.1	[1]8	--	--
POTOMAC RIVER BASIN											
01597500	SAV0037	46	106	7.13	25	--	--	.15	70	138	34
01599000	GEO0009	47	73	6.85	30	--	--	.37	48	249	21
01610000	POT2766	48	3,109	6.55	29	--	--	.51	[1]33	558	5
01613000	POT2386	49	4,073	5.29	34	3.75	46	.42	[1]43	281	18

U.S. Geological Survey streamflow site number	Water-quality site ID number	Map site number	Drainage area (square miles)	Total nitrogen as N		Nitrate nitrogen as N		Total phosphorus as P		Total suspended solids	
				Yield	Rank (54)	Yield	Rank (80)	Yield	Rank (75)	Yield	Rank (56)
01614500	CON0180	50	501	24.3	3	20.0	4	0.77	22	408	10
01619500	ANT0044	51	281	26.2	2	23.8	2	.95	11	271	19
01624800	1BCST012.32	52	70.1	10.9	12	7.89	20	.86	16	--	--
01625000	1BMDL001.83	53	375	5.04	36	3.50	50	.28	[1]60	[2]209	25
01626000	1BSTH027.85	54	127	3.47	39	2.70	61	.83	18	118	37
01627500	1BSTH007.80	55	212	4.08	37	3.88	45	.42	[1]43	162	30
01629500	1BSSF054.20	56	1,377	10.4	13	6.89	24	2.9	2	538	7
01631000	1BSSF003.56	57	1,642	5.62	33	4.65	37	.50	[1]35	173	28
01632000	1BNFS093.53	58	210	3.08	41	4.13	42	.26	64	--	--
01632900	1BSMT004.60	59	93.2	9.11	19	7.39	22	1.7	5	265	20
01634000	1BNFS010.34	60	768	[2]6.86	28	6.27	29	.36	[1]49	158	31
01634500	1BCDR013.29	61	103	[2]2.25	48	1.46	66	--	--	53.6	47
01635500	1BPSG001.36	62	87.8	1.94	52	.620	76	.20	[1]67	112	38
01637500	CAC0148	63	66.9	12.7	10	12.4	12	.49	[1]37	289	16
01638500	POT1595	64	9,651	9.49	18	6.81	25	.96	10	417	9
01639000	01639000	65	173	17.6	8	9.9	16	.92	13	--	--
01639500	BPC0035	66	102	21.6	4	16.5	7	.93	12	547	6
01643000	MON0155	67	817	18.7	7	15.2	9	1.8	4	1,170	2
01646000	1ADIF000.86	68	57.9	8.63	20	5.17	31	.59	27	--	--
01646580	PR01	69	11,570	12.0	11	[3]8.93	19	.84	17	[4]750	--
RAPPAHANNOCK RIVER BASIN											
01666500	3-ROB001.90	70	179	7.19	24	3.05	58	.81	19	--	--
01668000	01668000	71	1,596	6.16	32	[3]2.92	59	1.5	6	1,220	1
01669000	3-PIS009.24	72	28	2.50	47	1.15	69	--	--	53.9	46
MATTAPONI RIVER BASIN											
01674500	01674500	75	601	1.95	51	[3].420	80	.20	[1]67	40.0	50
PAMUNKEY RIVER BASIN											
01671020	8-NAR005.42	73	463	--	--	.52	79	.13	[1]71	47.9	49
01673000	01673000	74	1,081	2.87	44	[3].970	73	.33	[1]54	151	[1]32
JAMES RIVER BASIN											
02013100	2-JKS023.61	76	614	3.34	40	1.13	71	1.8	3	69.1	45
02020500	2-CFP004.67	77	144	1.82	53	.950	74	--	--	--	--
02021500	2-MRY038.10	78	329	1.50	54	.650	75	.33	[1]54	--	--
02026000	2-JMS229.14	79	3,683	[2]2.91	43	[2]1.33	68	[2].55	[1]30	[2]129	35
02027500	2-PNY005.29	80	47.6	2.94	42	1.89	64	--	--	--	--
02029000	2-JMS189.31	81	4,584	2.53	45	1.34	67	[2].52	32	151	[1]32
02035000	02035000	82	6,257	3.64	38	[3]1.14	70	.80	20	292	15
02037500	2-JMS117.35	83	6,758	2.52	46	1.02	72	.51	[1]33	678	3
APPOMATTOX RIVER BASIN											
02041650	02041650	84	1,344	2.10	49	[3].570	77	.23	66	53.6	[1]47

[1] Rank is tied because more than one yield had the same value.
[2] Mean yield is for calendar year 1993-95.
[3] Mean yield data represents dissolved nitrate plus nitrate nitrogen.
[4] Mean yield data represents total suspended sediment. Data are not included in the ranking.

the presence of large reservoirs behind each of three hydroelectric dams on the Susquehanna River between sites 34 and 36. As water enters these reservoirs, it slows, and suspended particulate matter is deposited. Because phosphorus adheres to particulate matter, phosphorus also is deposited. These three reservoirs annually trap an average of 40 percent of the total phosphorus load entering this river system (Ott and others, 1991).

Status yields for TSS were calculated at 56 of the 84 sites (table 1). TSS yields ranged from a maximum of 1,220 lb / acre (site 71) to a minimum of 13.8 lb / acre (site 15). Similar to phosphorus, the TSS status yield declines in the Lower Susquehanna River Basin, from 564 lb / acre (site 34) to 193 lb / acre (site 36). This is caused primarily by the estimated 70-percent sediment trapping efficiency in the reservoir system on the Lower Susquehanna River (Ott and others, 1991). Once the reservoirs fill, they will no longer trap sediments and nutrients, and loads to the Bay can be expected to increase by 70 percent for phosphorus and 250 percent for suspended sediment (Langland and Hainly, 1997). Although yields of total suspended solids and suspended sediments are not directly comparable because of analytical differences, the transport mechanism (streamflow) and depositional processes are similar. Suspended sediment status yields were calculated for nine USGS water-quality sites. If TSS data were available at any of the nine sites, then TSS yields were reported in table 1.

TRENDS

One way to measure the effects of nutrient-reduction strategies in the Chesapeake Bay Basin, and progress toward the nutrient-reduction goal, is to determine if any consistent changes through time, or trends, are evident in the concentrations of nutrients in the waters that enter the Bay. Across the basin, trends in the concentrations of both TN and TP were generally downward, indicating that nutrient-reduction strategies have had a positive effect on the water quality.

Trends in concentration were determined by use of a time coefficient in the ESTIMATOR model (Cohn and others, 1989). The trend results are corrected to account for both flow and seasonality. Where the trend is significant (95-percent significance level), the direction of the trend is indicated by upward or downward pointing arrows (figs. 2a-2d).

Trends in concentrations of TN were calculated for 54 sites. The trends were downward at 20 of the 54 sites (fig. 2a and table 2) and upward at six sites, four of which are in the Potomac River Basin (fig. 2a). Trends in concentrations of NO_3 were calculated for 81 sites (fig. 2b and table 2). NO_3 trends were upward at 19 sites and downward at 19 sites, but no significant change was detected at 47 sites. The upward trends may be related to (1) a “lag” between applications of fertilizers to the land surface and the delivery of NO_3 in the ground-water portion of streamflow, (2) climatic factors, such as variability in precipitation, that can vary the amount of NO_3 infiltrating the soils and reaching the ground water, (3) upgrades to sewage-treatment facilities that may change ammonia and organic forms of nitrogen to NO_3, and (4) possible higher concentrations of in-stream NO_3 as nitrogen-consuming plants (such as algae, a source of organic nitrogen) are limited due to in-stream decreases in phosphorus concentrations.

The positive effects of nutrient-reduction strategies are reflected by the downward trends in TP. Significant downward trends in TP were reported at 58 sites (fig. 2c and table 2), no change was reported at 17 sites, and TP was increasing at only 1 site. Reductions in concentrations from point-source discharges, especially sewage-treatment plants (U.S. Environmental Protection Agency, 1997), and the phosphate detergent ban (implemented throughout the basin in different years in the 1980’s) were major factors affecting the widespread downward TP trends in all 10 subbasins.

Significant downward trends for TSS were reported at 13 of the 56 sites. Upward TSS trends were reported at 4 sites—one each in the Patuxent, Choptank, Potomac, and James River Basins (fig. 2d and table 2). No significant trends in concentrations of TSS could be determined at 52 sites. At 10 of the 13 sites where TSS trends were downward, TP trends also were downward. Because a large portion of TP is attached to particulate matter (TSS), and the main transport mechanism for both constituents is surface-water runoff, nutrient-reduction strategies designed to control surface runoff would favorably affect both TSS and TP.

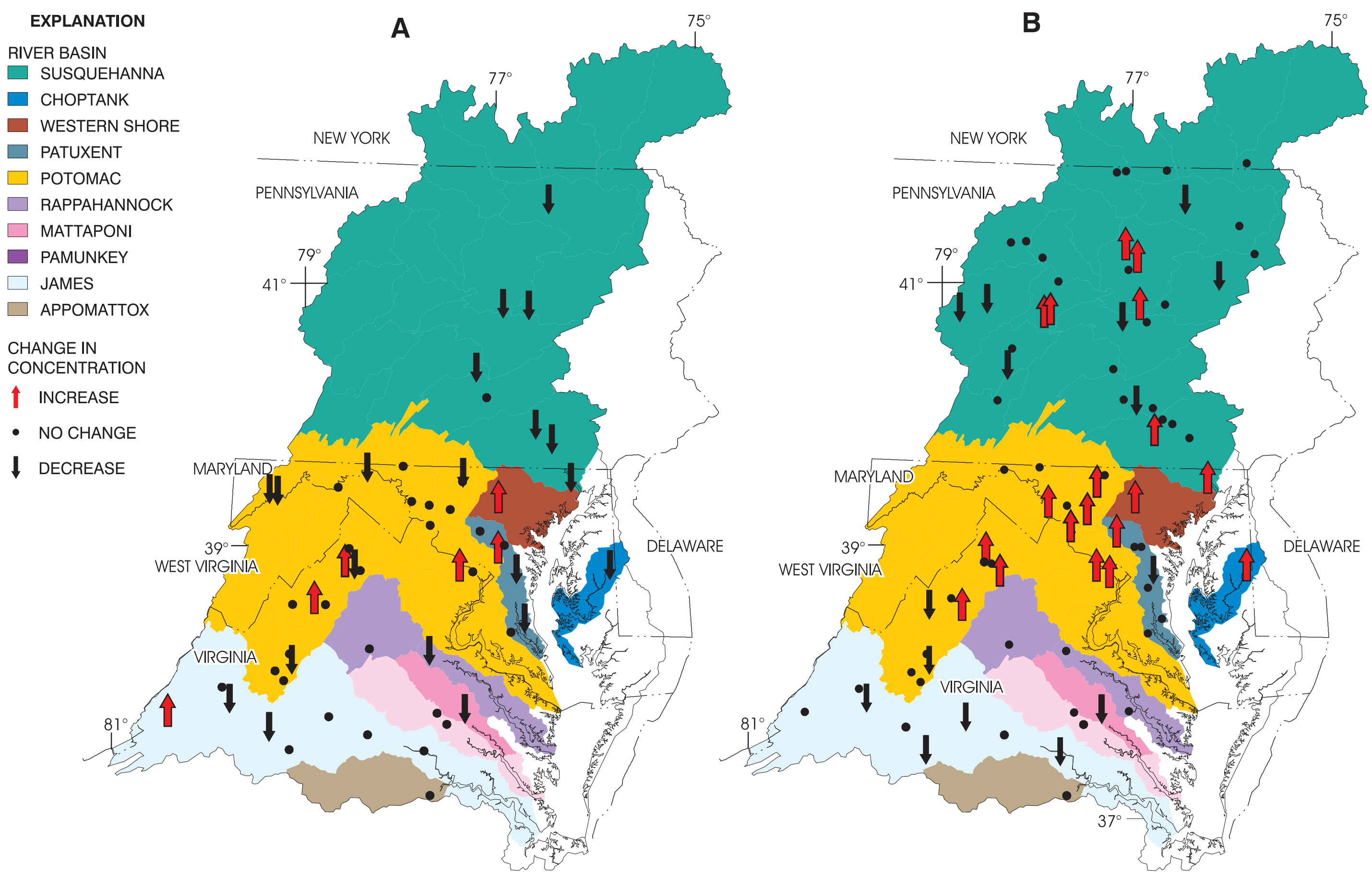

Figure 2. Trends in flow-adjusted concentrations of (A) total nitrogen, and (B) nitrate at stream sites in the Chesapeake Bay Basin.

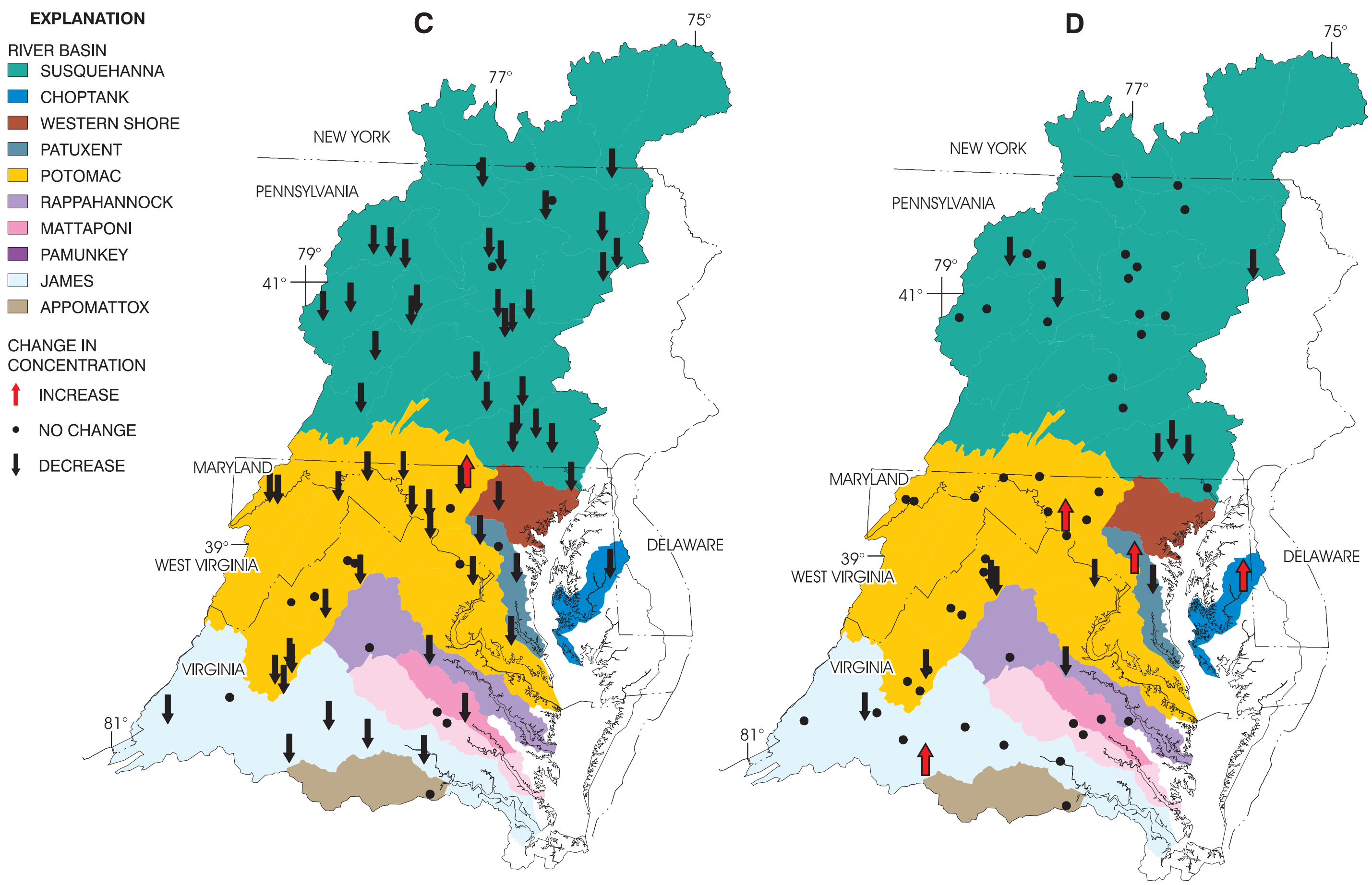

Figure 2. Trends in flow-adjusted concentrations of (C) total phosphorus, and (D) total suspended solids at stream sites in the Chesapeake Bay Basin—Continued.

Table 2. *Estimated flow-adjusted trends in concentrations of four constituents at 84 nontidal sites in the Chesapeake Bay Drainage basin for calendar years 1985-96*

[N, nitrogen; P, phosphorus; min and max define range in the change in concentration (at 95-percent confidence level); --, no results available; n/s, not significant at 95-percent confidence level; yellow, significant decrease in trend; red, significant increase in trend]

U.S. Geological Survey streamflow site number	Water-quality site ID number	Map site number	Drainage area (square miles)	Trends in concentration, in percent							
				Total nitrogen as N		Nitrate nitrogen as N		Total phosphorus as P		Total suspended solids	
				min	max	min	max	min	max	min	max
				SUSQUEHANNA RIVER BASIN							
01503000	WQN0306	1	2,232	--	--	n/s	n/s	-46	-15	--	--
01518700	WQN0319	2	446	--	--	n/s	n/s	-56	-21	n/s	n/s
01520000	WQN0320	3	298	--	--	n/s	n/s	n/s	n/s	n/s	n/s
[1]01531000	WQN0332	4	2,530	--	--	n/s	n/s	n/s	n/s	n/s	n/s
01531500	01531500	5	7,797	-47	-29	[2]-38	[2]-6	n/s	n/s	n/s	n/s
01532000	WQN0318	6	215	--	--	--	--	-64	-21	n/s	n/s
01534000	WQN0317	7	383	--	--	n/s	n/s	-52	-20	n/s	n/s
01536000	WQN0313	8	332	--	--	n/s	n/s	-53	-27	-86	-39
01536500	WQN0302	9	9,960	--	--	-52	-9	-69	-46	--	--
01540500	01540500	10	11,220	-37	-23	[2]n/s	[2]n/s	-41	-10	n/s	n/s
01541000	WQN0406	11	315	--	--	-42	-20	-86	-65	n/s	n/s
[1]01541500	WQN0422	12	371	--	--	-40	-12	-42	-7	n/s	n/s
[1]01543000	WQN0420	13	272	--	--	n/s	n/s	-55	-29	-87	-19
[1]01544000	WQN0419	14	245	--	--	n/s	n/s	-69	-38	n/s	n/s
[1]01545000	WQN0434	15	233	--	--	n/s	n/s	-57	-26	n/s	n/s
01546500	WQN0415	16	87.2	--	--	2	26	-62	-32	n/s	n/s
01547200	WQN0413	17	265	--	--	2	36	-73	-57	-93	-8
01547950	WQN0423	18	152	--	--	n/s	n/s	--	--	n/s	n/s
01550000	WQN0409	19	173	--	--	34	67	-66	-19	n/s	n/s
01551500	WQN0402	20	5,682	--	--	n/s	n/s	n/s	n/s	n/s	n/s
01552000	WQN0408	21	443	--	--	37	84	-69	-32	n/s	n/s
01553500	01553500	22	6,850	-24	-4	[2]8	[2]29	-33	14	n/s	n/s
01554000	WQN0203	23	18,300	--	--	n/s	n/s	-62	-38	--	--
[1]01555000	WQN0229	24	310	--	--	-35	-3	-49	-4	n/s	n/s
01556000	WQN0224	25	291	--	--	-34	-9	-78	-64	--	--

U.S. Geological Survey streamflow site number	Water-quality site ID number	Map site number	Drainage area (square miles)	Trends in concentration, in percent							
				Total nitrogen as N		Nitrate nitrogen as N		Total phosphorus as P		Total suspended solids	
				min	max	min	max	min	max	min	max
01558000	WQN0217	26	220	--	--	n/s	n/s	-82	-69	--	--
01562000	WQN0223	27	756	--	--	n/s	n/s	-78	-61	--	--
01567000	01567000	28	3,354	-31	-21	[2]n/s	[2]n/s	-59	-41	n/s	n/s
[1]01570000	WQN0213	29	470	--	--	n/s	n/s	-53	-1	n/s	n/s
[1]01570500	01570500	30	24,100	--	--	[2]-38	[2]-4	--	--	--	--
01573560	WQN0211	31	483	--	--	n/s	n/s	-64	-41	--	--
01574000	WQNO210	32	510	--	--	n/s	n/s	-67	-49	--	--
[1]01575500	WQN0207	33	222	--	--	30	100	-76	-43	-84	-39
01576000	0157600	34	25,990	-37	-22	[2]n/s	[2]n/s	-47	-20	-77	-12
01576754	01576754	35	470	-23	-14	n/s	n/s	-23	-6	-70	-5
01578310	01578310	36	27,100	-25	-10	[2]1	[2]24	-62	-52	n/s	n/s
CHOPTANK RIVER BASIN											
01491000	01491000	37	113	-18	-1	[2]22	[2]55	-41	-5	3	250
WESTERN SHORE RIVER BASIN											
01586000	NPA0165	38	56.6	19	46	29	66	-81	-48	n/s	n/s
PATUXENT RIVER BASIN											
01591000	PXT0972	39	34.8	n/s	n/s	8	40	-72	-30	n/s	n/s
01592500	PXT0809	40	132	1	30	n/s	n/s	n/s	n/s	14	213
01594000	01594000	41	98.4	n/s	n/s	n/s	n/s	--	--	--	--
01594440	01594440	42	348	-60	-53	[2]-55	[2]-44	-80	-71	-53	-25
01594526	01594526	43	89.7	--	--	n/s	n/s	--	--	--	--
[1]01594670	01594670	44	9.4	-47	-15	n/s	n/s	--	--	--	--
01594710	01594710	45	3.3	n/s	n/s	[2]n/s	[2]n/s	-74	-21	--	--
POTOMAC RIVER BASIN											
01597500	SAV0037	46	106	-48	-29	--	--	-65	-4	n/s	n/s
01599000	GEO0009	47	73	-46	-19	--	--	-64	-11	n/s	n/s
01610000	POT2766	48	3,109	n/s	n/s	[2]n/s	[2]n/s	-72	-36	n/s	n/s
01613000	POT2386	49	4,073	-45	-19	n/s	n/s	-65	-9	n/s	n/s
01614500	CON0180	50	501	n/s	n/s	n/s	n/s	-54	-15	n/s	n/s
01619500	ANT0044	51	281	n/s	n/s	13	48	-46	-17	n/s	n/s
01624800	1BCST012.32	52	70.1	n/s	n/s	n/s	n/s	-54	-19	n/s	n/s
01625000	1BMDL001.83	53	375	n/s	n/s	n/s	n/s	-72	-47	-73	-24
01626000	1BSTH027.85	54	127	n/s	n/s	n/s	n/s	-52	-10	n/s	n/s
01627500	1BSTH007.80	55	212	-81	-69	-71	-54	-73	-54	n/s	n/s
01629500	1BSSF054.20	56	1,377	n/s	n/s	1	39	-53	-24	n/s	n/s
01631000	1BSSF003.56	57	1,642	n/s	n/s	0	77	-68	-28	-72	-72
01632000	1BNFS093.53	58	210	n/s	n/s	-50	-1	n/s	n/s	n/s	n/s
01632900	1BSMT004.60	59	93.2	2	48	n/s	n/s	n/s	n/s	n/s	n/s
01634000	1BNFS010.34	60	768	22	88	54	215	n/s	n/s	n/s	n/s
01634500	1BCDR013.29	61	103	n/s	n/s	n/s	n/s	--	--	n/s	n/s
01635500	1BPSG001.36	62	87.8	-46	-5	n/s	n/s	n/s	n/s	-84	-22
01637500	CAC0148	63	66.9	n/s	n/s	n/s	n/s	-55	-8	61	484
01638500	POT1595	64	9,651	n/s	n/s	9	57	-60	-20	n/s	n/s
01639000	01639000	65	173	-76	-27	n/s	n/s	2	53	--	--
01639500	BPC0035	66	102	n/s	n/s	11	34	-63	-18	n/s	n/s
01643000	MON0155	67	817	n/s	n/s	76	198	n/s	n/s	n/s	n/s
01646000	1ADIF000.86	68	57.9	22	95	41	132	n/s	n/s	-76	-7
01646580	PR01	69	11,570	n/s	n/s	[2]52	[2]91	-58	-42	--	--
RAPPAHANNOCK RIVER BASIN											
01666500	3-ROB001.90	70	179	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s
[1]01668000	01668000	71	1,596	-36	-15	n/s	n/s	-53	-22	-72	-39
[1]01669000	3-PIS009.24	72	28	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s
MATTAPONI RIVER BASIN											
[1]01674500	01674500	75	601	-23	-7	-49	-21	-30	-5	n/s	n/s
PAMUNKEY RIVER BASIN											
01671020	8-NAR005.42	73	463	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s
[1]01673000	01673000	74	1,081	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s
JAMES RIVER BASIN											
02013100	2-JKS023.61	76	614	15	58	n/s	n/s	-86	-66	n/s	n/s
02020500	2-CFP004.67	77	144	n/s	n/s	n/s	n/s	--	--	-87	-24
02021500	2-MRY038.10	78	329	-37	-4	-64	-21	n/s	n/s	n/s	n/s
02026000	2-JMS229.14	79	3,683	n/s	n/s	-51	-8	-52	-11	8	208
02027500	2-PNY005.29	80	47.6	-83	-5	n/s	n/s	--	--	n/s	n/s
02029000	2-JMS189.31	81	4,584	n/s	n/s	-65	-20	-57	-17	n/s	n/s
[1]02035000	02035000	82	6,257	n/s	n/s	n/s	n/s	-49	-23	n/s	n/s
02037500	2-JMS117.35	83	6,758	n/s	n/s	-77	-24	-75	-52	n/s	n/s
[1]02041650	02041650	84	1,344	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s

[1] Trend time period other than 1985-96

[2] Trend for constituent nitrite plus nitrate (NO_2 plus NO_3)

SUMMARY

In support of the 1997 Reevaluation of the Chesapeake Bay Program, water-quality yield and trend data from 1985-96 were analyzed at 84 nontidal sites within 10 major subbasins of the Chesapeake Bay Basin. A mean yield was calculated for total nitrogen, total nitrate, total phosphorus, and total suspended solids at 54, 80, 75, and 56 sites, respectively, for the last 3 years of record. The highest yields were reported at sites in subbasins having a large percentage of agricultural land use, and lowest yields were reported in subbasins with large amounts of forested land. Generally, basinwide trends from 1985 to 1996 for both total nitrogen and total phosphorus were downward, indicating the positive effects of nutrient-reduction strategies. Trends for nitrate nitrogen, however, were either upward or not statistically significant at about 75 percent of the sites, suggesting that nutrient-reduction strategies for nitrate nitrogen are less effective or that more time is needed to detect significant changes in water quality.

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